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Original research

Concurrent rib and pelvic fractures as an indicator of solid abdominal organ injury☆

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ABSTRACT

Objectives: To study the association of solid organ injuries (SOIs) in patients with concurrent rib and pelvic fractures.
Methods: Retrospective analysis of prospectively collected data from November 2007 to May 2010. Patients' demographics, mechanism of injury, Injury severity scoring, pelvic fracture, and SOIs were analyzed. Patients with SOIs were compared in rib fractures with and without pelvic fracture.
Results: The study included 829 patients (460 with rib fractures ± pelvic fracture and 369 with pelvic fracture alone) with mean age of 35 ± 12.7 years. Motor vehicle crashes (45%) and falls from height (30%) were the most common mechanism of injury. The overall incidence of SOIs in this study was 22% (185/829). Further, 15% of patient with rib fractures had associated pelvic fracture. SOI was predominant in patients with concurrent rib fracture and pelvic fracture compared to ribs or pelvic fractures alone (42% vs. 26% vs. 15%, respectively, $p = 0.02$).
Conclusions: Concurrent multiple rib fractures and pelvic fracture increases the risk of SOI compared to either group alone. Lower RFs and pelvic fracture had higher association for SOI and could be used as an early indicator of the presence of SOIs.

1. Introduction

Rib fractures are common chest injuries resulting from high force blunt trauma. It is difficult to determine the exact incidence of rib fractures among seriously injured patients due to insensitivity of routine chest radiography.[1] Furthermore, the clinical bedside diagnosis of intraabdominal injuries is difficult in those patients who are at risk for intraabdominal injury.[2,3] At present, accurate diagnosis of intra-abdominal injuries in hemodynamically stable patients is primarily based on abdominal CT scanning.[4,5]

The majority of the patients with rib fracture due to blunt trauma have significant associated injuries.[6–9]

Patient with lower rib fractures of the right side are more likely to have liver injury, whereas left-sided fractures are more susceptible toward splenic injury.[9,10] Pelvic fracture is an indicator of severe trauma and is often associated with major intraabdominal injuries.[11] Though the incidence of pelvic fractures after blunt trauma is relatively high, it had lesser association with severe complications.[11] Eastridge et al., showed that not only the pelvic fracture but also, the associated complications such as neurologic (27%), thoracic (26%) and abdominal (14%) injuries correlated with the collision force and severity in blunt trauma patients.[12] It is also noted that in patients with severe pelvic fractures (Abbreviated Injury Score ≥4), the incidence of associated injuries was notably higher (31%).[11]

We, previously, reported on association of lower rib fractures with an increased incidence of solid organ injury (SOI).[13] To the best

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of our knowledge, there is no report available on the association between rib, pelvic fracture and abdominal SOI.

Using rib and pelvic fractures as an indicator of blunt trauma force, the association of both fractures with intra-abdominal injuries was studied with the objective to determine whether a significant relationship exists between the occurrence of these fractures and the incidence of associated SOI.

2. Methods

Hamad General Hospital, the tertiary care medical facility in Doha, Qatar, provides all levels of medical services to the entire population and receives all major trauma patients from the country. Trauma surgeons from initial assessment and resuscitation, thru operation, intensive care and in-hospital care, manage the injured patients. Following an initial review of our experience, data were collected and analyzed retrospectively for all patients admitted with multiple rib fractures and presence of pelvic fracture during the period from November 2007 to May 2010.

Demographics, mechanism of injury, Injury Severity Score (ISS), presence of pelvic fracture, rib fracture (number and location) and associated abdominal SOIs were analyzed for all cases and controls. Initial clinical assessment was performed according to Advanced Trauma Life Support protocols. All patients included in the study were assessed by initial supine chest and pelvic radiographs followed by computed tomography scan of chest and abdomen. The solid organs injury (SOI) of the abdomen constituted liver, spleen, and kidneys. SOI was compared in rib fracture patients with and without pelvic fractures. Data were presented as proportions, mean ± standard deviation (SD) and range as appropriate. Baseline demographic characteristics, presentation and outcomes were compared using the student-*t* test for continuous variables and Pearson chi-square (X^2) test for categorical variables. A significant difference was considered when the *P* value was less than 0.05. All data analyses were carried out using the Statistical Package for Social Sciences version 18 (SPSS Inc. USA). The study was approved by Medical Research Center, HMC, Qatar (IRB#10062/10).

3. Results

The study cohort included 829 patients who sustained blunt traumatic injury, of which 460 had multiple rib fractures (with and without associated pelvic fracture) and 369 had isolated pelvic fracture. The majority of patients were males (93%), with a mean age of 35 ± 12.7 years.

The mechanism of injury: Motor vehicle crash (206; 45%) and fall from height (139; 30%) were the most common mechanism of injury (Fig. 1).

Fig. 2 shows the overview of the study results. In the study group, concurrent rib and pelvic fracture was observed in 69 (15%) cases. whereas, 391 (85%) cases had rib fracture alone. Moreover, 369 patients with pelvic fracture alone were included as controls. The overall incidence of SOIs in this study was 22% (185/829). SOIs were identified in 130 (28.3%) patients in the study group and in 55 (15%) patients of the control group. Fig. 3 shows that SOI was predominant in patients with concurrent rib fracture and pelvic fracture compared to ribs or pelvic fractures alone (42% vs. 26% vs. 15%, respectively, $p = 0.02$).

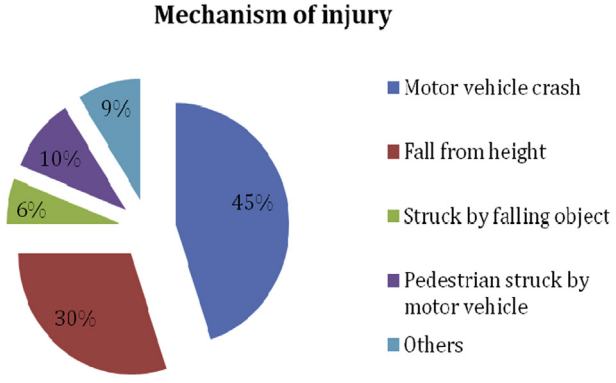

Fig. 1. Mechanism of injury.

The most common injured organ was spleen followed by liver and kidney. Median abdomen AIS was 3 (1–4) whereas median ISS was 13 (1–45). ISS was higher in the study group when compared to the control group [(13 (4–66) vs. 9 (4–50); $p < 0.001$)]. Further, in patients with SOI, the presence of pelvic fractures was associated with higher ISS in comparison to those who had isolated rib fracture (Table 1).

SOIs were graded according to American Association for the Surgery of Trauma – Organ Injury Scale (AAST/OIS) as mild to moderate (grade I, II) in 123 patients and severe (grade III, IV) in 51 patients. No association was observed between pelvic fracture and number of rib fractures, as the majority (78%) of cases had <5 fractured ribs.

Table 2 shows the number of patients presenting with concurrent pelvic fracture and rib fracture (either isolated or overlapping rib zones). The majority of patients with pelvic fractures were reported in the presence of overlapping middle and upper rib zones (42%) followed by overlapping lower and middle rib zones (26%).

Table 3 shows the number of patients presenting with solid organ injury in the presence of concurrent pelvic fracture and rib fracture (either isolated or overlapping rib zones). SOIs were mainly encountered in patients with pelvic fracture in the presence of overlapping lower and middle rib zones (62%) followed by isolated lower rib zone (50%).

4. Discussion

The present study reports that the presence of pelvic fracture increases the incidence of associated SOI in patients with rib fracture. The overall incidence of SOIs in this study was 22%. The incidence of SOI was significantly higher in patients with combined rib and pelvic fractures compared to either rib or pelvic fractures alone.

An increased risk of abdominal SOIs in patients of lower rib fracture has been reported earlier.[14–16] Consistent with these reports, this study also shows higher association of SOI with lower rib fractures and overlapping lower and middle rib zones which also corroborates with our previous report.[13]

The rising incidence of road traffic crashes is a most important public health problem in the civil society. In particular, blunt chest injury and pelvic fractures are associated with increased morbidity and mortality. The chest wall and soft tissues are the most commonly affected sites by blunt trauma. The site of fracture has important impact on the clinical presentation. Fractured ribs 4–10 are more frequent in trauma, whereas, fractured ribs 8–12 increases the likelihood of the presence of associated abdominal injuries.[14]

Surprisingly, there are only few reports on the potential additive impact of pelvic or long bone fractures on the likelihood of associated abdominal injuries. Shweiki et al. reviewed 476 hospitalized traumatic rib fracture patients and concluded that in patients with rib fracture, presence of pelvic fractures and long bone fractures did not increase the likelihood of associated SOI.[9] In contrast, our study showed increased association of SOI and concurrent multiple rib and pelvic fractures. It also demonstrates high predictability for SOI with concurrent pelvic and lower rib fractures. Pelvic fractures are reportedly the third most common cause of death in motor vehicle crashes, after central nervous system and chest injuries.[17] Pelvic injuries, especially those involving disruption of the pelvic ring, signify high energy trauma. Such injuries are seen in motor vehicle crashes and in falls from considerable height, precisely the largest groups represented in this study.

Parriera et al., demonstrated that outcome was more closely related to the associated injuries than to the pelvic injuries per se.[18] Demetriades et al., also showed high incidence of associated

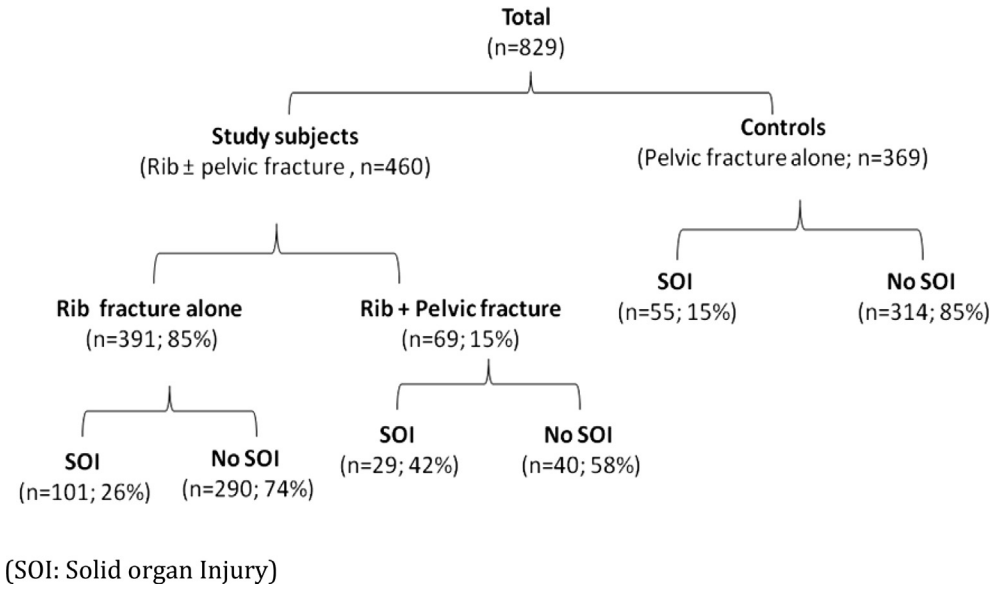

Fig. 2. Overview of study results.

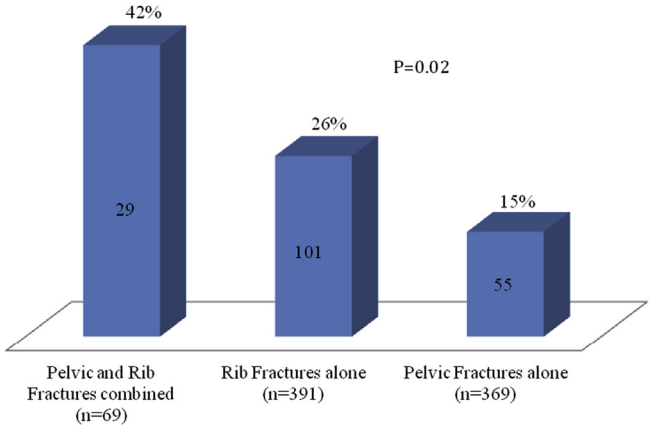

Fig. 3. Incidence of solid organ injuries in relation to pelvic and rib fracture.

abdominal injuries among adults and pediatric trauma patients and liver was the most common injured organ.[11,19] In patients with complex pelvic fractures, the spleen was found to be the most frequently injured solid organ followed by liver.[20,21] In our study, the incidence of liver and splenic injuries were comparable in patients with concurrent rib and pelvic fractures.

The association of intra-abdominal injuries with pelvic fractures is well recognized. Bond et al., reported an incidence of 20% of associated intra-abdominal injuries in pediatric pelvic fractures patients.[22] The high incidence of associated abdominal injuries (42%) in this study was probably due to exclusion of simple pelvic avulsion fractures and higher median Injury Severity Score.

Table 1
Injury severity score according to rib and pelvic fracture with associated solid organ injury.

Solid organ injury	Injury severity score (median; range)
Rib + pelvic fracture ($n = 29$)	22 (9–41)
Rib fracture alone ($n = 101$)	13 (5–45)
Pelvic fracture alone ($n = 55$)	22 (8–50)
No solid organ injury ($n = 314$)	13 (4–60)

Table 2
Number of patients presenting with concurrent pelvic fracture and rib fracture (either isolated or overlapping rib zones).

	Lower ribs	Middle ribs	Upper ribs
Lower ribs	8	26	–
Middle ribs	26	9	42
Upper ribs	–	42	18

Table 3
Number of patients presenting with solid organ injury in the presence of concurrent pelvic fracture and rib fracture (either isolated or overlapping rib zones).

	Lower ribs	Middle ribs	Upper ribs
Lower ribs	4/8 (50%)	16/26 (62%)	–
Middle ribs	16/26 (62%)	4/9 (44%)	18/42 (43%)
Upper ribs	–	18/42 (43%)	6/18 (33%)

4.1. Limitations

The important limitations of the study included the retrospective nature of the study, small number of patients and the overlap between the locations of fractured ribs.

Particularly, there was an overlap between the adjacent lower and middle ribs and also between middle and upper ribs. Further, the types of pelvic fracture were not given clearly.

5. Conclusions

The concurrent clinical findings of fractures of the lower ribs and, pelvic fracture after blunt trauma pose a high risk for intra-abdominal SOI. Association of multiple rib fractures and pelvic fracture increases the risk of SOI compared to either group occurring separately.

Contrarily, rib fracture patients without concurrent pelvic fracture are at a lower risk of intra-abdominal injury. Therefore, the presence of pelvic fracture and multiple ribs fracture should be considered as a potential indicator for possible solid organ injury.

Ethical approval

The study was approved by Medical Research Center, Hamad Medical Corporation, Qatar (IRB#10062/10).

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Author contribution

Ammar Al-Hassani (Lead investigator & writing manuscript), Ibrahim Afifi (data collection), H Abdelrahman (data collection & review manuscript), Ammar Al Madani (data collection), J Recicar (review manuscript), Ayman El-Menyar (data analysis & writing & review manuscript), Rifat Latifi (review manuscript), Hassan Al Thani (review manuscript), K Maull (review manuscript).

Conflict of interest

None.

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